

What is claimed:

1. An isolated DNA molecule encoding a protein exhibiting alkaline liquefying α -amylase activity at a pH optimum of 8-9 and possessing an amino acid sequence obtained by modifying an amino acid sequence described in SEQ ID NO: 2 in a manner in which one or more amino acids are substituted, deleted, or inserted without changing the enzymological properties of the protein having said amino acid sequence described in SEQ ID NO:2 and the protein hydrolyzes 1,4- α -glucosidic linkages in starches, amylose, amylopectin, and degradation products thereof and in amylose forms: glucose (G1), maltose (G2), maltotriose (G3), maltotetrose (G4), maltopentose (G5) and maltohexose (G6) and does not hydrolyze pullulan.

2. The DNA molecule of claim 1, further comprising a nucleotide sequence for regulating expression of said isolated DNA molecule.

3. A recombinant DNA molecule comprising the isolated DNA molecule of claim 1.

4. A recombinant DNA molecule comprising the isolated DNA molecule of claim 2.

5. The DNA molecule of claim 1, wherein said encoded protein has an isoelectric point higher than 8.5 when measured by isoelectric focusing electrophoresis.

6. The DNA molecule of claim 1, wherein said encoded protein:

acts in a pH range of 5.0 to 11.0, with an optimum pH in the range of 8.0 to 9.0;

is stable in a pH range of 5.0 to 10.5 and retains at least 50% of activity after treatment at 40°C for 30 minutes;

acts in a temperature range of 20°C to 80°C, with an optimum temperature in the range of 45°C to 55°C;

is stable at temperatures of 50°C or lower when treated for 30 minutes in a glycine-salt-sodium hydroxide buffer having pH 8.5;

has a molecular weight of 50,000 \pm 5000 when measured by sodium dodecyl sulfate polyacrylamide gel electrophoresis;

has an isoelectric point of approximately 9.2 when measured by isoelectric focusing electrophoresis;

is stable in the presence of K⁺, Na⁺, Ca²⁺, Mg²⁺, Mn²⁺, Ba²⁺, Fe²⁺, Fe³⁺, or Al³⁺; and

is substantially free of inhibition by surfactants selected from the group consisting of sodium linear alkylbenzene sulfonates, sodium alkylsulfonate esters, sodium polyoxyethylene alkylsulfate esters, sodium alkylsulfonates, soaps and polyoxyethylene alkyl ethers.

7. An isolated DNA molecule encoding a protein exhibiting alkaline liquefying α -amylase activity at a pH optimum of 8-9 comprising at least one nucleotide sequence that is selected from the group consisting of SEQ ID NO: 10, SEQ ID NO: 7, SEQ ID NO: 3, SEQ ID NO: 6 and SEQ ID NO: 9.

8. An isolated DNA molecule encoding a protein exhibiting alkaline liquefying α -amylase activity at a pH optimum of 8-9 comprising at least one nucleotide sequence that is the reverse complement of a sequence selected from the group consisting of SEQ ID NO: 8, SEQ ID NO: 4 and SEQ ID NO: 11.

9. An isolated DNA molecule encoding a protein exhibiting alkaline liquefying α -amylase activity at a pH optimum of 8-9 comprising at least one nucleotide sequence selected from the group consisting of SEQ ID NO: 10, SEQ ID NO: 7, SEQ ID NO: 3, SEQ ID NO: 6 and SEQ ID NO: 9, and also comprising at least one nucleotide sequence that is the reverse complement of a sequence selected from the group consisting of SEQ ID NO: 8, SEQ ID NO: 4 and SEQ ID NO: 11.